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AUGUST 23, 1982

C8700-1 8/23/82

THE JOURNAL OF TELECOMMUNICATIONS SINCE 1901

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August 23, 1982
VOLUME 203
No. 8

telephony

(ISSN 0040-2656)

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Published weekly by TELEPHONY PUBLISHING CORP., 55 E. Jackson, Chicago, IL 60604
Telephone 312/922-2435; TWX 910 221 1058

European Bureau, 136 Broomfield Rd., Chelmsford, Essex CM1 1RN, England;
Telephone Chelmsford (0245) 58257;
Telex 995801 GLOTLX-G.

*Except twice weekly the 2nd week of September and three times during the month of December. Officers of Telephony Publishing Corp. are Dan S. Fargo, President; H.D. Fargo, Jr., Vice President & Treasurer; Leo Anderson, Del Myers and Ed Robinson, Vice Presidents. Postmaster: Please send form 3579 to Subscription Dept., TELEPHONY, 55 E. Jackson Blvd., Chicago IL 60604.
Second class postage paid at Chicago, Ill., and at additional mailing offices. Single copies (payable in advance) U.S. $3.00 ea., issues over 2 years old $3.50 ea. Outside U.S. add $1.00 ea.

Subscriptions: $26 one year. Outside U.S. add $19 per year. Subscription rates apply to employes of operating telephone companies; telephone consultants, contractors; interconnect co's; specialized common carriers; military govt assn's; private communications users; schools; libraries. All others $32 one year. Outside U.S. add $19 per year. Change of address: include old address as well as new address. Attach issue label if possible. Allow 4 weeks for change to become effective.

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Undersea cable systems plunge into the waters of new technology

Here's how undersea cable systems are moving with the flow of technological developments, in order to maintain a competitive position in the global telecommunications network

B.M. DAWIDZIUK

LAST MAY, the British Telecom cableship *Monarch* laid the U.K. end of a new transatlantic cable, TAT-7, and the actual construction of yet another major intercontinental communications artery quietly began. The capacity of this new transatlantic cable is 4200 basic voice grade circuits capable of further expansion by the use of the circuit multiplication equipment of Time assignment speech interpolation or similar type.

Measured in terms of the design capacity of the contemporary International Telecommunications Satellite Organization ((INTELSAT) satellites, or INTELSAT-V, this new cable appears to be relatively small. Yet, recognizing that the cable systems provide mainly point-to-point circuit facilities, and in practice the configured capacity of any operational satellite is well below its design capacity, the importance of the TAT-7 cable as one of the key elements of the North Atlantic communication network becomes apparent. Clearly, superficial analysis of loosely related facts can easily lead to misleading opinions, or conclusions. This article will provide basic facts about undersea systems achievements, their role and their future.

Undersea cable systems are well established as the principal element of the global network. This is evident when statistics are examined in detail. Table 1 summarizes the status of the global cable network at the end of 1981.

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Cover photo by Cable & Wireless

Cable is carefully loaded into the Cable Venture, *a cable ship.*

The facts given in Table 1 are impressive. They cover cumulative developments since 1950, the year the first repeatered cables were introduced in service over short distances in the North Sea and the Caribbean. This is reflected in the relatively low equivalent average system capacity of 700 circuits, because the early cable systems had 60 or 120 circuit capacity. This was a large capacity at the time of installation.

Of course, allowances were made for systems that have been withdrawn from the network, such as the TAT-1 cable phased out of operation in November 1978 after 22 years of successful service.

But Table 1 gives little information about the recent developments in the global cable network. Taking as an example a period of the last 5 years, similar statistics show a more interesting picture (Table 2).

The $1.2 billion invested in undersea cable systems during the last 5 years represents approximately 31% of the cumulative total capital cost of the cable network to date. The network itself, when measured in terms of circuit miles, has increased by 42%. The average capacity of installed systems has been significantly increased. This reflects the installation of modern, high capacity systems.

Considering that in the same period, INTELSAT consolidated its network by the widespread deployment of the INTELSAT IVA satellites and the introduction, in 1981, of the new generation of INTELSAT V satellites, the development of the global cable network is remarkable. These numbers do not include major transoceanic systems currently under construction, such as TAT-7.

Currently, there are approximately 16 cable systems under construction for several national telecom

Table 1

Status of global cable network (End of 1981)

Number of operational cable links	214
Total cable route mileage	140,500 nm
Total cable network size	98.6 m circuits/nm
Equivalent average system capacity	700 circuits
Cumulative investment in cable systems	$2.9 billion

administrations (PTTs) and international service carriers. There are a variety of systems. Some are major, multisegment transoceanic cables. Others are short, or medium length inter- or intraregion systems. The underlying desire to ensure operational diversity and network security is reflected in the current construction of three transoceanic systems. These will significantly contribute to the cable network capacity, and the resultant investment in this technology.

Details of the construction program for such transoceanic systems are given in Table 3. The most recent project—the ANZCAN system—warrants special mention, because it represents an important development in the Pacific Ocean. The main link is between Australia and Canada with the intermediate terminal points in Norfolk Island, Fiji and Hawaii. As a part of the ANZCAN system there is a branch cable connecting New Zealand with Norfolk Island. Some segments will be ready for service during 1983, but the complete system will be operational in 1984.

The combined route of the three transoceanic systems is 15,225 nautical miles. They will add 31.1 million circuit miles to the existing cable network capacity, an increase of about 32% above the network position at the end of 1981.

This is not all. There are 13 regional systems under construction covering almost every major maritime area (Table 4).

Another $550 million has been committed by the co-owners of these facilities to cover the systems described in Table 4. When these current projects are completed by August of 1984, the total global cable network is likely to consist of 235 separate cable links, offering 144.6 million circuit miles. The cumulative investment would reach $4.25 billion.

This is not the end of the story because up to this point only firm projects have been included in the overall network statistics. Many new systems are in various stages of planning. Out of necessity, information is only tentative, but it clearly indicates the important role that undersea systems will play in the make-up and traffic distribution of the global communications network in the late 1980s.

The recent expansion of the cable network in Southeast Asia has strengthened the position of Singapore as the major communication center of the area. Plans for new cable systems radiating from Singapore are expected to be finalized in the near future. The main aim would be to interconnect Southeast Asia with the Middle East and Mediterranean, and then with Europe. Such a project is now under evaluation regarding the final routing and system capacity for each individual cable segment. It is likely that the route will connect Singapore with Indonesia, Sri Lanka, Djibouti, Saudi Arabia, Egypt, Italy and France. It will be truly transoceanic in magnitude. Another cable linking Singapore with the Far East also is under study and the final details are expected to be known in the near future.

Undersea cable systems are now being introduced between the Gulf states. Planning is in progress to connect the Indian subcontinent with the Gulf and East Africa.

New cables are being actively planned for the Caribbean region. The Federal Communications Commission (FCC), is due to commence the evaluation of these plans in the near future. This FCC activity will follow the completion of the planning process for the Pacific region. Last May, the FCC published the notice of proposed rulemaking, which authorizes the investment by the United States Independent Service Carriers in the ANZCAN system. The proposed Pacific plan also includes construction of the continental U.S. to Hawaii No. 4 cable, and a transpacific link from Hawaii to Japan. The target date for this next transpacific cable is 1988.

The North Atlantic facilities planning process, established as part of the activity leading to the final approval by the FCC of the TAT-7 cable in 1979, is addressing the long term future of the transatlantic communications. Current plans assume construction of the next cable—TAT-8—in 1988. It will be the first transoceanic application of the new generation of digital submarine systems.

During the late 1970s there was rapid development of undersea system technology. Systems with bandwidths of 25, 28, 36 and 45 MHz (megahertz) were progressively in-

Continued on page 28

Table 2

Growth of global cable network during the last five years (1977-1981)

Number of cable links installed	48
Total added cable route mileage	26,640
Total added network capacity	41.1m circuit/nm
Equivalent average system capacity of added cables	1540 circuits
Associated investment in these cable systems	$1.2 billion

troduced into service in 1976 and 1977 by various administrations. These systems offer a basic capacity between 2500 and 5500 voice grade circuits.

Current system designs offer a whole range of circuit capacities, covering low, medium and high traffic density routes. They range between 480 and 5520 circuits depending upon the system bandwidth and the multiplex arrangements. The majority are capable of crossing transatlantic distances, including the highest capacity 45 MHz system.

In the late 1970s advanced laboratory research and development work addressed the technical feasibility of even larger bandwidth systems, capable of providing 10,000 to 15,000 circuit capacity. Outline designs are available for undersea analog systems with about 15,000 circuit capacity working at 140 MHz line frequency. Using conventional coaxial cable, the repeater spacing becomes very close—about 3.4 km. Undoubtedly, such systems would be economical for high traffic density routes.

However, 140 MHz analog systems are unlikely to be implemented, since the recent trend is towards digital capability. There are many reasons for this, some valid, others based upon expectations of potential economic benefits—if a number of key assumptions prove to be achievable.

There are four undisputed facts. One, switching systems are changing to digital operation. Two, local networks in many countries have been using pulse code modulation systems for several years. Three, a number of countries with mature telecommunications networks already have long distance digital network overlays. Four, INTELSAT is introducing time-division multiplex access (TDMA) as a part of the operational requirement for INTELSAT-V satellites.

The demand for digital transmission capability has also affected the direction of undersea cable systems research and development programs. Extensive studies have shown that a direct application of digital transmission on conventional coaxial undersea cable is not economically feasible. An alternative approach, capable of economically providing a four-wire working arrangement, is essential. Here, optical fibers offer exciting possibilities provided the necessary and traditionally accepted high design reliability of all new system elements can be achieved when it is needed and without undue economic penalties.

Sufficient design studies supported by laboratory evaluations have been done on optical undersea cable systems to confirm the feasibility of this new technology. The question is not if such systems are possible, but when can the necessary reliable engineering work be completed to provide the required confidence for the use of this new technology.

It takes time to translate early laboratory experiments of a new technology into mature engineering applications. This is especially so in the field of highly reliable and durable products currently in use for the underseas cable network of the world.

There appears to be a consensus of opinion between the various countries having undersea cable system design capability that early experimental systems are likely to appear around 1984 or 1985. The first commercial applications on a regional basis are expected to follow about 2 years later. Early candidates for the construction of operational undersea optical fiber systems are several routes in Europe where further cable capacity will be required on major trunk routes in the

Continued on page 30

Table 3

Transoceanic cable systems under construction (June of 1982)

Route	Service date	Capacity	Route length nm
Atlantis South (Brazil-Senegal)	1982	1380	1780
Atlantis North (Senegal-Portugal)	1982	2580	1620
TAT-7 (U.S.A.-U.K.)	1983	4200	3290
ANZCAN (Main link: Australia-Canada)	1984	1380	7740
ANZCAN (branch: New Zealand-Norfolk Island)	1983	480	735

Table 4

Regional cable systems under construction (June of 1982)

Region	Number of systems	Combined route length
North Sea/European Atlantic coast	5	1277
Mediterranean	3	1317
South east Asia	3	1458
The Gulf	1	474
Caribbean	1	1220
Total	13	5746

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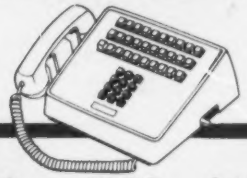

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North Sea, Atlantic and Mediterranean.

The first transoceanic optical fiber system is planned for 1988. This probably will be the TAT-8 cable linking the U.S. and Europe (see article p. 32). Various configurations are still under study, but this link could provide basic system capacity in the range of 8000 to 12,000 circuits. A significant increase in this capacity can be readily achieved by the use of digital speech interpolation (DSI). The final deciding factor of system capacity will be traffic requirements, rather than technology limitations.

Soon after the construction of the TAT-8 system, an optical underseas cable is expected to be installed across the Pacific following and consistent with the proposed FCC rulemaking on Pacific facilities.

This new undersea cable technology is likely to offer several advantages. Besides being a natural digital transmission medium, it will offer:

- large capacity systems limited only by the specific route traffic requirements;
- modular capacity using standard electronic modules, and variable numbers of fiber pairs in one cable structure for a given route;
- underwater branching units, which could allow two or three separate landing points at both ends of the system, if specifically desired by the co-owners;
- ease of deploying DSI to increase significantly the total utilization of the basic system bandwidth; and
- attractive system economics if the full potential for cost reduction due to significantly increased repeater spacing for high capacity systems is achieved in practice—the basic cost of high quality fiber will be one of the key economic parameters deciding the final level of system economics.

In order to achieve the potential economic benefits of this new technology, undersea optical cables will use monomode fibers. The first systems are likely to operate at 1.3 micron wavelength. At this wavelength repeater spacing of some 30 km is practical for operation at 280 Mbps (megabits per second) per pair of fibers enclosed in a cable structure which is less than 1 in. in diameter. In the case of a 280 Mbps equivalent analog system (45 MHz system), repeaters have to be inserted every 5.4 km using 1.5 in. cable. This is just one example of the potential benefits offered by the introduction of fiber optics for undersea telecommunications.

As with the case of terrestrial systems, the transition to digital and to fiber optics will be gradual, and is likely to take the best part of this decade.

Existing designs of analog systems are being, and will be, ordered for some time to come. The ANZCAN project is a good example. The plans for the Indian Ocean cable are also based upon analog technology. Digital systems are perfect for digital traffic. Otherwise, conversion from analog (A) to digital (D), or from D to A is necessary.

Despite the extensive volume of published material, in reality there are currently few countries that have extensive digital traffic. Many advanced countries are still finding difficulties in direct TDMA access to the INTELSAT-V system, because D to A conversion is necessary for traffic extension from the satellite earth station to the main traffic centers.

The world is gradually moving from A to D in all forms of telecommunication network operation and hardware. Undersea cable technology is also moving in that direction, not only to keep abreast of the technological developments but to maintain its competitive position as one of the principal elements of the global telecommunications network of the future.

As the status of the current global cable network programs demonstrate, cable technology has been accepted as an essential element in the drive for a highly diversified network structure.

Modern automation and annually increasing volumes of traffic demand total network reliability, excellent circuit quality and low costs. These key attributes are already being offered by the existing analog undersea cable systems. In the future, when all potential economic and configuration benefits of the optical fiber systems will be realized, the basic attractiveness of cable systems will be further increased. Thus, the complementary satellite technology might find itself under extreme competitive pressure from the cable alternative.

In these circumstances, satellites are likely to be used more for the broadcast mode for which they are ideally suited, with cable systems providing the heavy trunk routes of the global communication network of the 1990s. □